Title: Update on MPDV Diagnostic and Data

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Update on MDPV Diagnostic and Data

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Update on MPDV Diagnostic and Data

- MPDV Diagnostic
  - Latest MPDV System - Gen 4
  - MBR – Modulation Based Ranging
- MPDV Late Time Data
- Future Work
  - LDRD – addressing loss of late time data
  - MPDV heating of HE
  - Incorporate error analysis in MPDV data

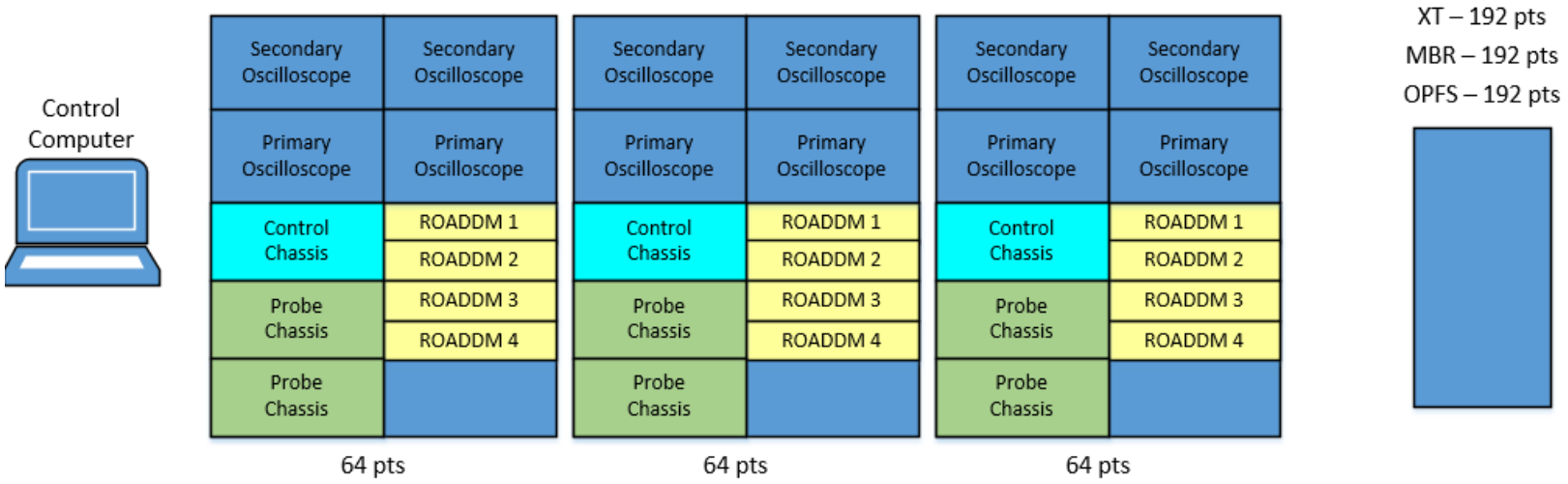
Designs of MPDV Gen 3 and Gen 4

- Gen 3 Design
  - 128 points of MPDV
  - Operate at high power (200 mW)
  - Counter propagation in ROADDM
  - Multiplexed 16 in-time, 16 channels per ROADDM, 128 channels requires 4 ROADDMs)
  - System couldn't be operated at full power because of SBS (launch power limited to about 20 mW)
- Gen 4 Design:
  - 192 points of MPDV AND 192 points of MBR
  - Operate at high power (200 mw) without SBS
  - Counter propagation in ROADDM
  - Modified Gen 3 by redesigning ROADDM, 8 channels per ROADDM, 192 channels requires 12 ROADDMs (+ spare)
  - Stabilize optical power over MPDV data collection - feedback stabilization of launch power based on return signal to increase dynamic range

Optical Power Considerations

- Why is 200 mW considered the maximum operating optical power?
  - Manufacturer spec on power per fiber in MT connector is 150 mW
  - MPDV typical operation < 200 mW
  - MPDV demonstrated at much greater power, but damage to connectors was observed
- What optical power is required?
  - High signal to noise over entire trace
  - Constant optical power over entire trace
    - Jump off data is very important to XTD designers for optical shots. Establishes timing between optical and gas cavity experiments
    - Designers would like to see data up to probe impact
  - Optical power decays from first motion
- Will high optical power damage the probe?
  - We have design for new probe does not have index matching gel
  - Need to test optical power threshold
- Does the heating of HE during MPDV Tuning cause a safety and data concern)
  - LANL system has been designed to limit tuning at high power to 3 minutes
  - Will perform experiment planned to measure HE heating by MPDV system in realistic geometry

Gen 4 Rack Configuration

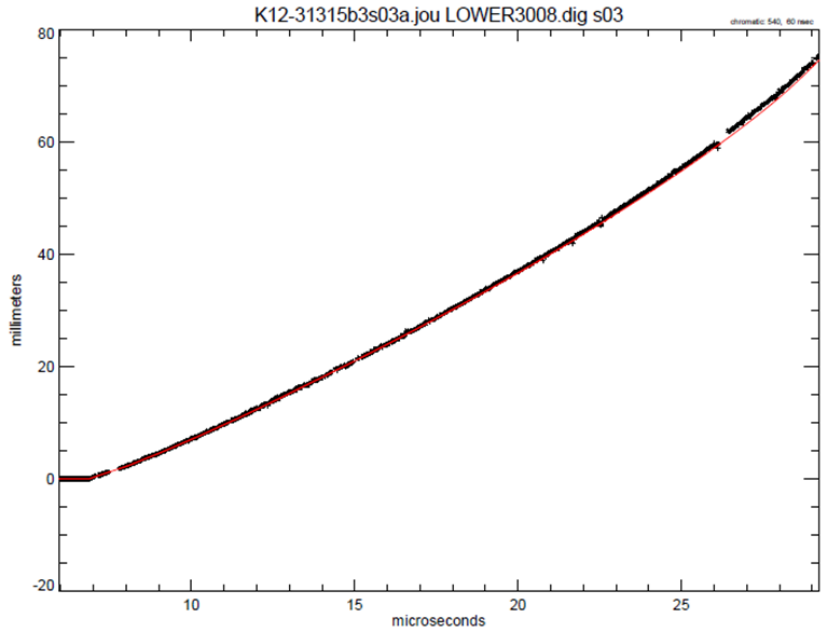


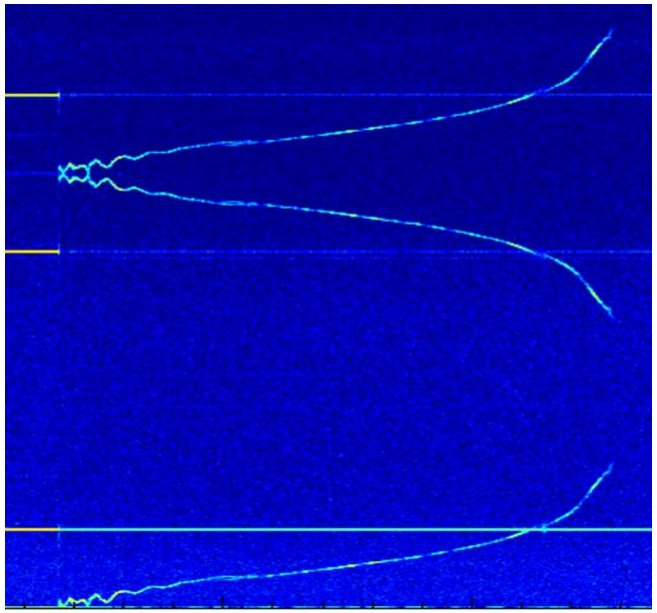
64 Points:

- Multiplex 8 time
- 1 Control Chassis
- 2 Probe Chassis
- 4 ROADDMS (16 pts per ROADDM)
- 2 Primary Scope : 8 pts/ch
- 2 Secondary Scope: 8 pts/ch

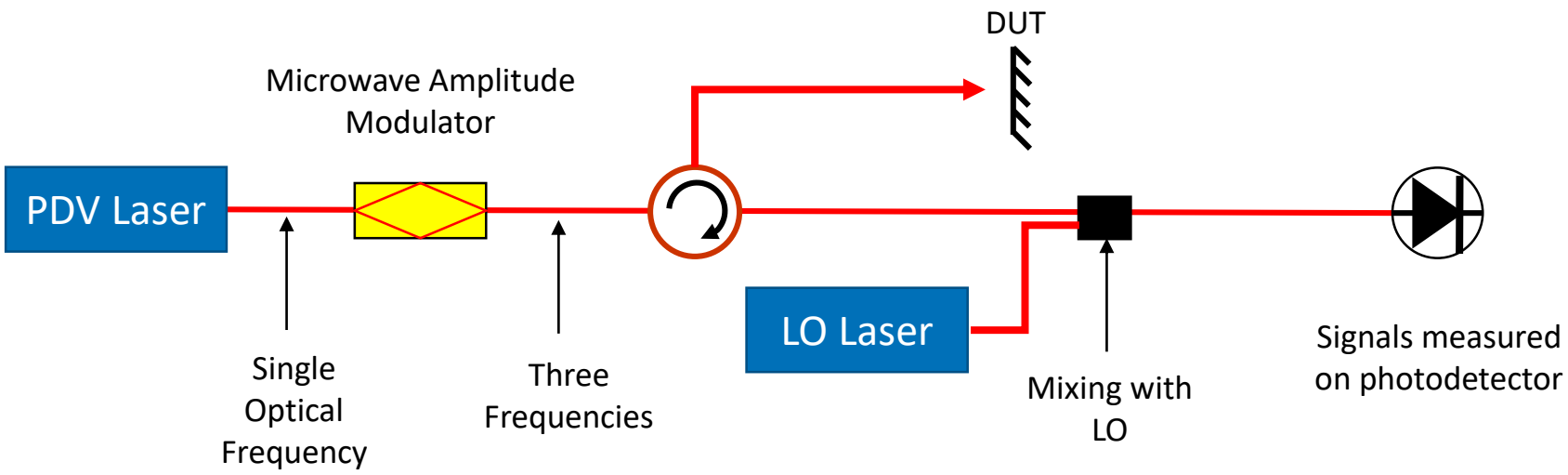
Modulation Based Ranging (MBR)

- MBR - Direct measurement of implosion surface position
  - MBR is sensitive to non-radial flow.
  - Integrated MPDV does not detect non-radial flow
- Easily implemented on any existing PDV/MPDV architecture.
- Uses existing MPDV optical paths identical beamlines
- Easy to setup and operate
- Inexpensive: ~$1k / channel
- Natural redundancy in the velocity measurement with the inclusion of MBR
- True 25 µm accuracy with 200 mW launch power





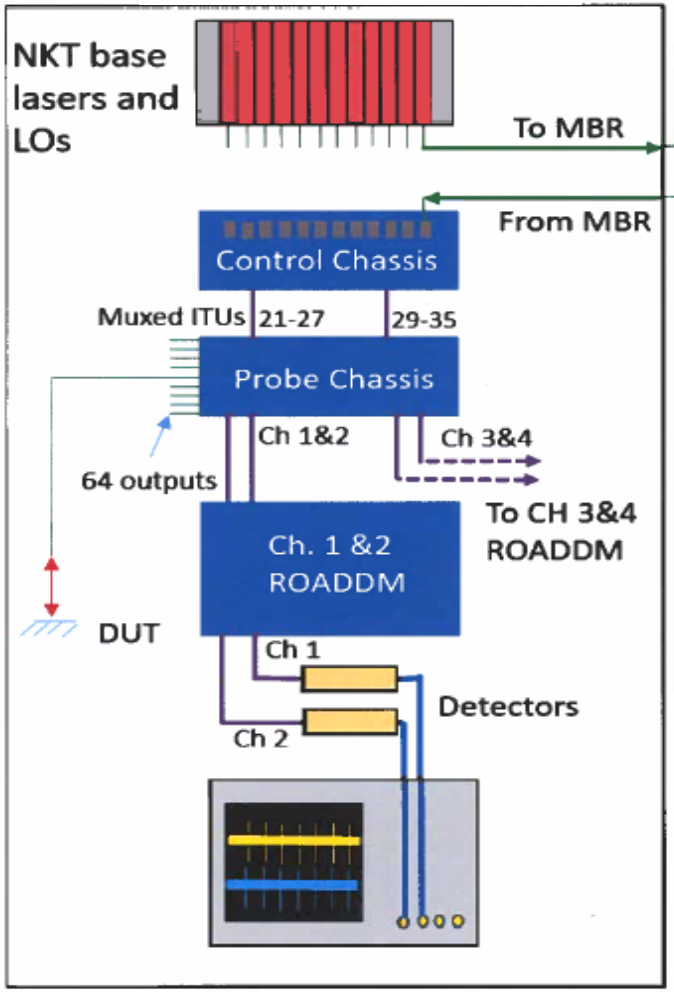
Addition of Displacement Measurements to MPDV



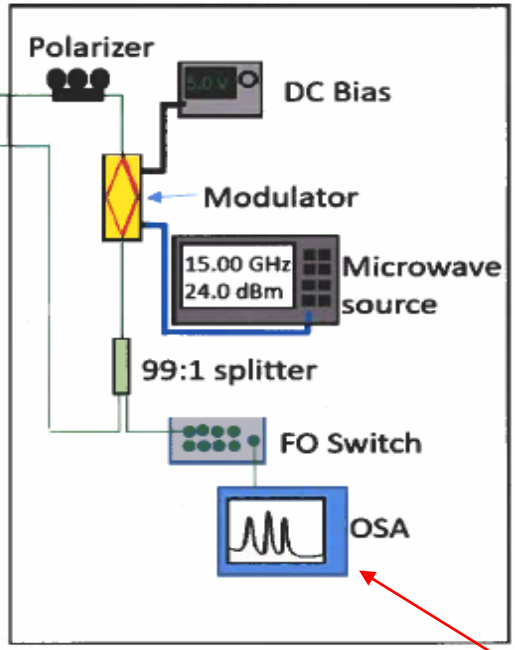
- Three distinct signals are created by the modulator and sent to the surface.
- The three signals are mixed with the LO and detected on a photodetector.
- The phases of the signals are extracted and compared. The phase of the microwave frequency is calculated which is the desired displacement measurement.

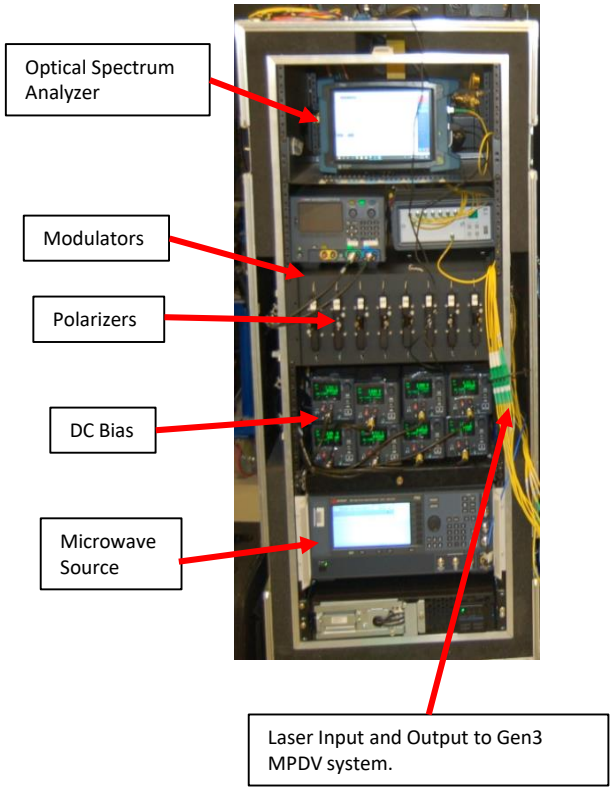
MBR Experimental Setup

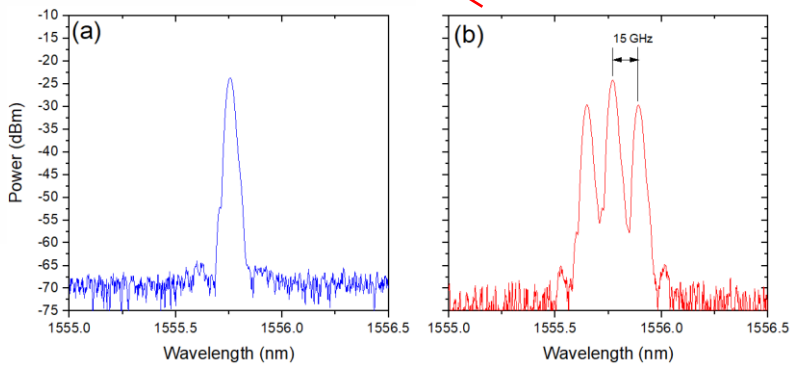
Standard MPDV rack



MBR Rack





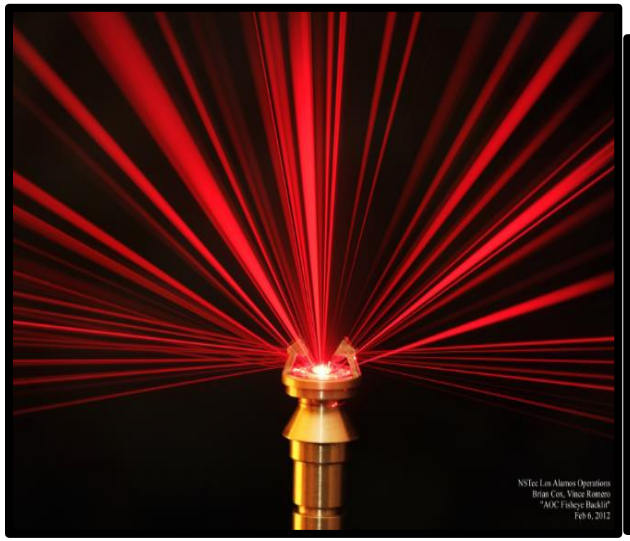


Effort to Improve MPDV Data

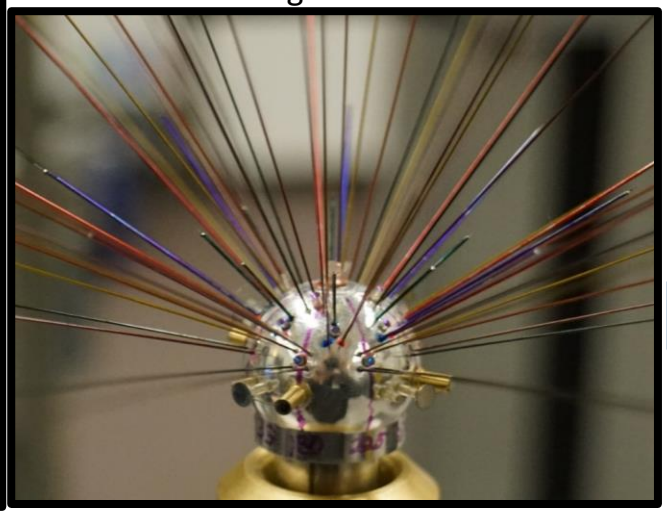
- Is “missing” late time data providing information of the performance of the system?
  - Similar data with electrical pins (Pins – methane, Optical – vacuum)
  - Use gas fill to “hold back” spray
  - New optical diagnostics specifically designed for late time data
- Is the Hydro Assembly impacting the late time data?
  - Joints (design, build, eliminate)
  - HE cutouts vs. BH slidecone (3-D modeling)
  - All parts in tolerance
- Is the diagnostic limiting the data?
  - Probe – size, fisheye vs. discrete
  - Blast Hardware – interface with probe and weapon system – our design of our BH isolates probe from BH
- Is the MPDV system not performing as well at late time?
  - Increase optical power
  - Optical power compensation (feedback stabilization)
  - MBR – direct measurement of position for every PDV point

LDRD Goals

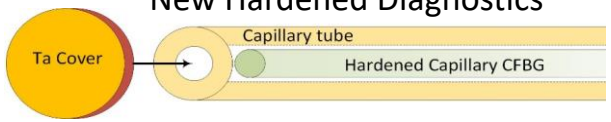
- Reanalyze all previous hydrotests MPDV data with same set of tools and confirm causes of signal drop out.
- Design experiments to test various hypotheses on causes of early signal dropout.
- Design and test new diagnostics for obtaining late time data.
- Design new integrated diagnostic dome for large-scale test.
- Perform modeling efforts on previous hydrotests to determine effects of reduced number of diagnostic points and reduced number of late time data points.
- Update MPDV early signal drop out hypotheses list.
- Test new MPDV Gen 4 system. The new MPDV Gen 4 system is due to be completed in FY22 QTR 2 and will have a series of experiments to validate improvements.



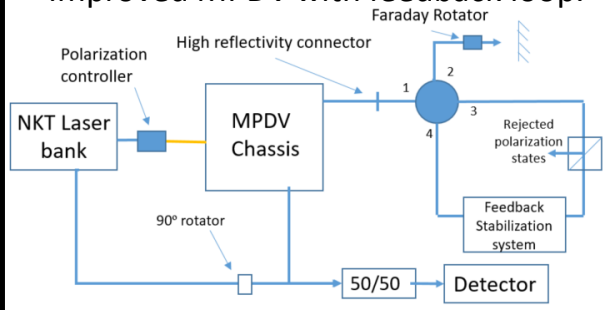
New Diagnostics Probe

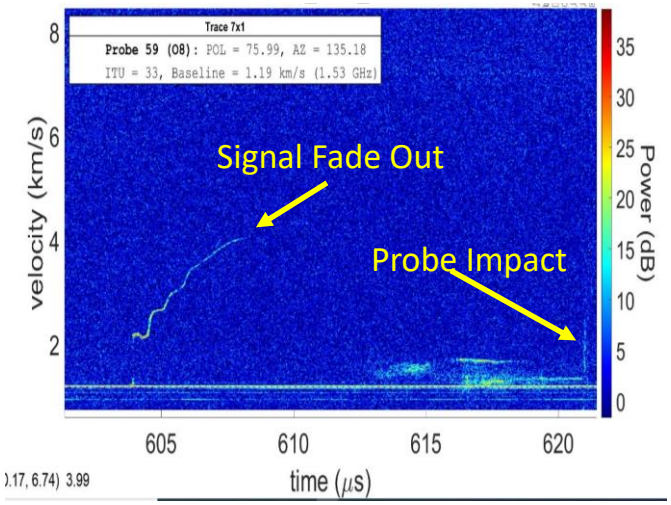


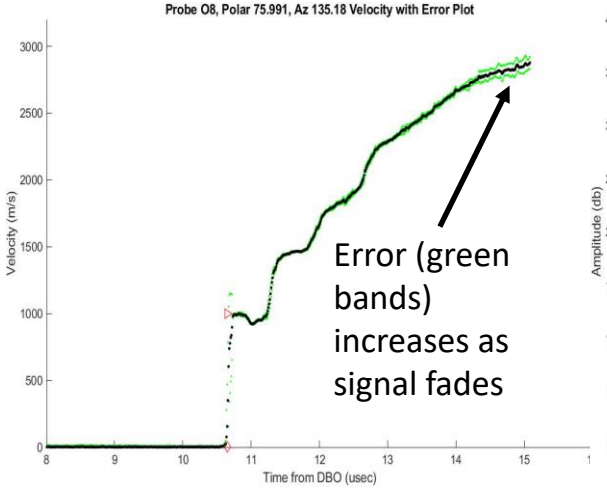
New Hardened Diagnostics

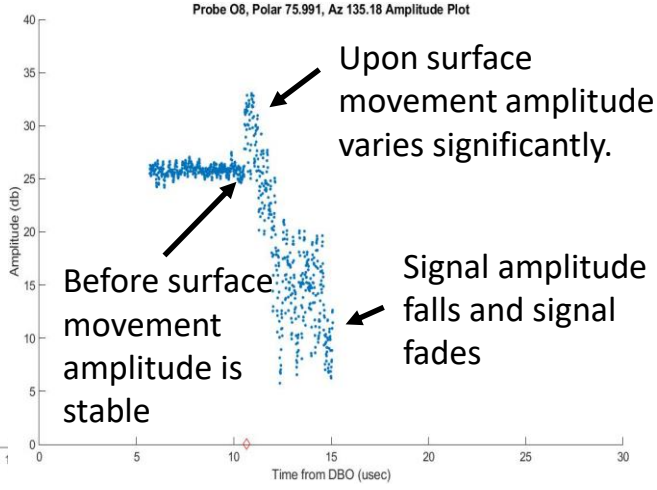


Improved MPDV with feedback loop.

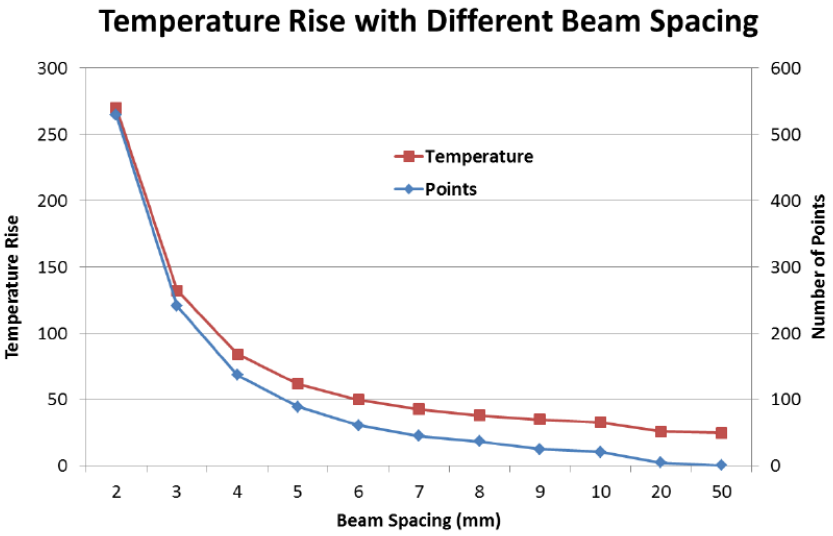


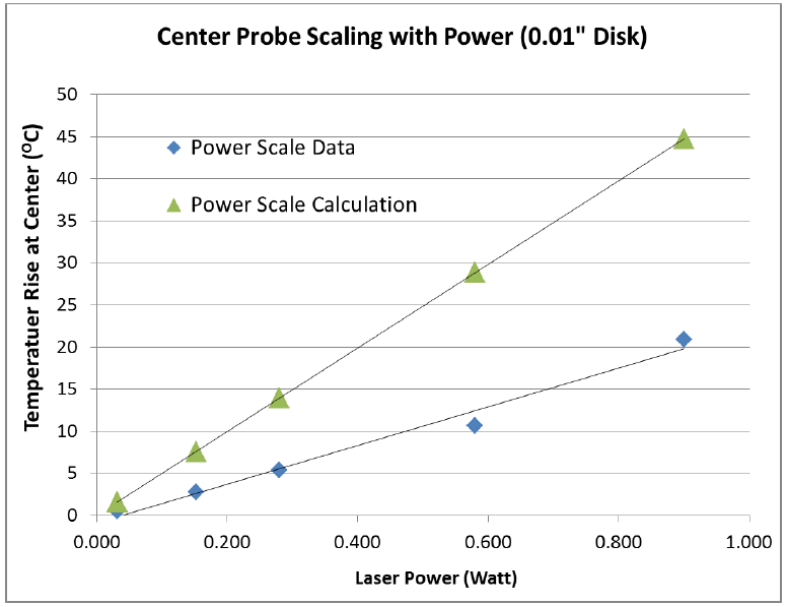






HE Heating Modeling Summary



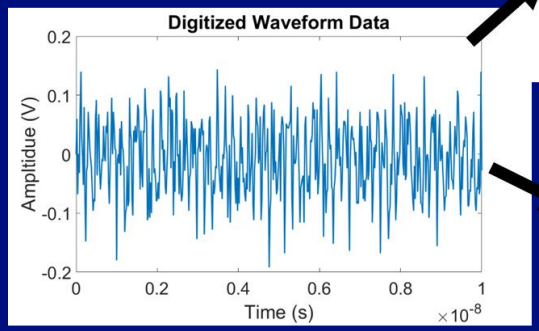


- In a one probe model, an incident beam of 1 W significantly (20 °C) heated a metal disk. We expected to see a large change in temperature when we applied 7 W to a metal hemisphere surrounded by high explosives.
- In Gen4 MPDV, each probe launches 200 mW. The number and density of probes will absolutely affect the heating of the device.

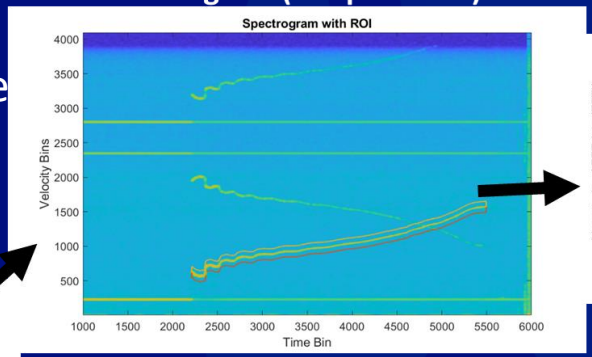
M. Pickrell, LA-UR-18-28033 and LA-UR-18-28061

Uncertainty Analysis of PDV Traces

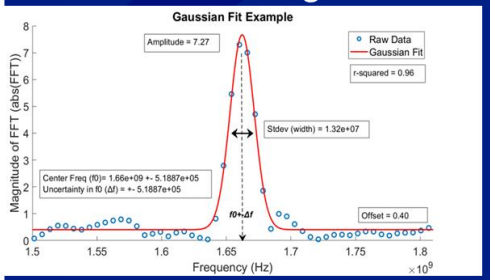
- The velocity profile and its associated uncertainty can be extracted from frequency analysis of the PDV signal. We apply two models to characterize the frequency response.
  1. Local Gaussian fitting in frequency domain
  2. Cosine Fitting directly in time domain



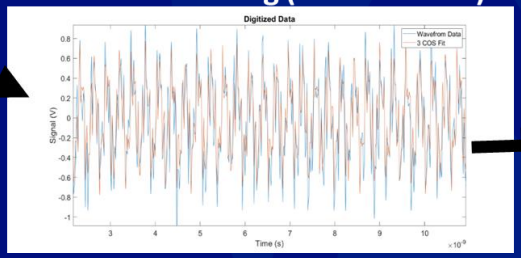
Sliding FFT (Freq Domain)



Local Gaussian Fitting On ROI



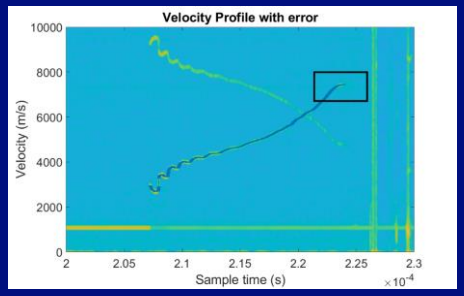
Cosine Fitting (time domain)

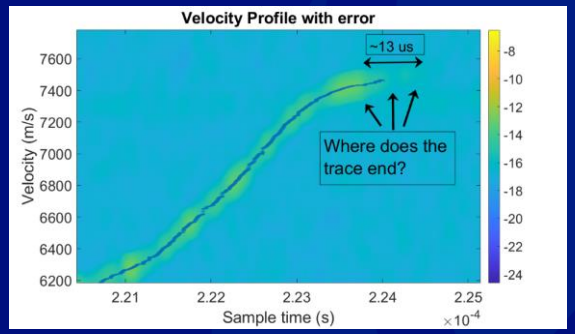


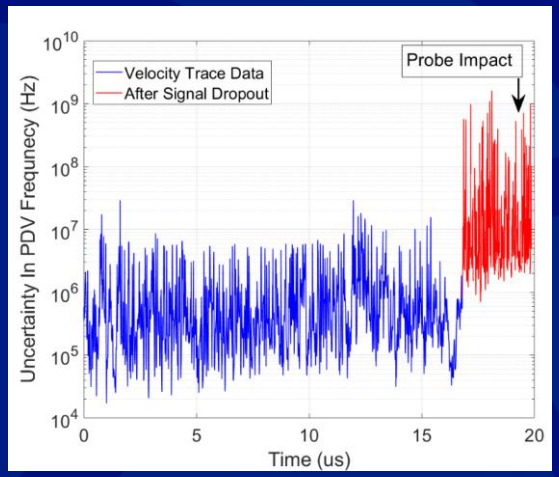
Fitting Results:
- Frequency (velocity)
- Uncertainty in velocity
- Signal/Noise ratio
- Dropout?

Sliding FFT (Freq Domain)

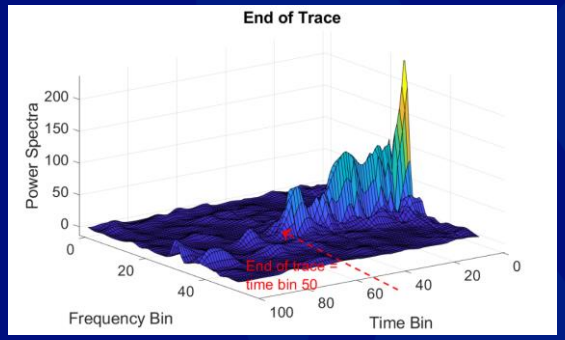
Fitting of PDV Allows for Robust Quantification of Uncertainty, Signal Dropouts, Jump-Off, and End-of-Trace

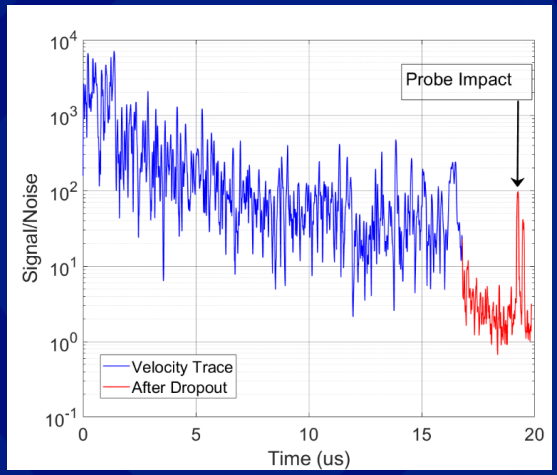






- Gaussian fitting parameters (signal/noise, uncertainties, r-squared) allow for automated ROI generation and end-of-trace determination.
- Error of ~2 µs possible by eye





Conclusion

- Gen4 looks very promising
- Future in depth discussions would be useful
  - Methane pressure in cavity
  - 3 D modeling of blast hardware
  - Late time data